SECTION 3.3

RENEWABLE ENERGY ASSESSMENT

INTRODUCTION

Renewable energy is defined as energy from resources that are not depletable or are naturally replenished when used at sustainable levels. Renewable energy resources included here are hydropower, solar, wind, biomass, ocean, and landfill gas. In addition to these renewable resources, fuel cell technology is included because fuel cells provide potentially significant, long-run environmental and economic benefits to New York, can be powered with renewable energy, need support for commercialization, and have market barriers similar to barriers for renewable energy development.[1]

BENEFITS OF RENEWABLE ENERGY

Use of renewable energy provides a number of benefits. These can be broadly defined as:

Increased energy diversity and security;

Reduction in air emissions (particulates, NO_x, SO_x, greenhouse gases);

Economic development opportunities; and

Distributed generation.

Dependence on a limited number of energy resources can lead to greater potential for fuel supply interruptions, greater price volatility, and ultimately affect energy and economic security. Energy from renewable resources, such as wind and solar, is not fuel-dependent, and therefore, is not subject to the effects of natural and artificial fuel supply constraints.

Fossil-fueled electric generating plants are responsible for approximately one-third of nitrogen oxide (NO_x) emissions, two-thirds of sulfur dioxide (SO_2)

[1] Characterizations of selected renewable technologies and technical potential in New York are presented at the end of this section.

emissions, and one-quarter of carbon dioxide (CO_2) emissions, nationally. In New York, each megawatt-hour (MWh) of electricity generation, given the State's current mix of generation sources, produces 1.5 pounds of NO_x emissions, 3 pounds of SO_2 emissions, and 882 pounds of CO_2 emissions, annually. Power generation using renewable energy resources, such as wind, results in no air, water, or waste impacts.[2] Combustion of fossil fuels results in the release of CO_2, a significant contributor to global warming. Methane, the main energy component of landfill gas, is a particularly potent greenhouse gas, having roughly 21 times the global-warming effects of carbon dioxide. In many parts of the country, cities and counties are using landfill gas to produce electricity, heat, or steam for industrial use. These projects consume gases that, if not collected, could pose serious odor, safety, and environmental hazards if allowed to escape into the atmosphere.

In-State manufacturing of renewable energy equipment, such as photovoltaic (PV) systems and components, could lead to new industries with high export potential, leading to job creation. Deployment of renewable energy technologies can also lead to new jobs. For example, production of electricity from biomass requires labor to maintain the equipment and to grow, harvest, and transport the fuel. From the point of view of the State economy, much of the revenue for manufacturing, installing, fueling, and operating renewable power equipment can be retained instead of leaving the State to pay for imported fuels.

A number of benefits result from onsite power generation using renewable technologies. These include:

Reduced customer electricity load and demand charges;

Increased electricity system reliability;

Avoided investments in transmission and distribution infrastructure;

Waste heat recovery and avoided transmission losses; and

Availability of power in remote locations

The following benefits are specific to individual technologies:

Fuel cells improve power quality for industrial processes;

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[2] No energy source is completely environmentally benign. For example, potential wind energy impacts are aesthetics, noise, and communication interference, to name a few.

Electricity from wind can help meet winter electricity demand peaks; and

PV can be used to meet peak electricity demand during hot sunny days by generating power to meet air conditioning loads.

BARRIERS TO RENEWABLE ENERGY DEVELOPMENT

The more common barriers to the development and widespread use of renewable energy technologies can be broadly categorized as:

Price-related (premium);

Infrastructure-related (lack of infrastructure for the manufacture, sales, and service);

Educational (lack of customer familiarity with, and acceptance of, renewable energy resources).

Currently, using renewable energy technologies to produce electricity is more expensive than producing electricity from fossil fuels. For bulk power producers, higher costs results in increased project risk and raises the cost of financing. For onsite generation, the low cost of grid-connected power results in long payback periods for renewable energy systems. However, although renewable energy is more expensive to produce and purchase compared to energy from fossil fuels, its use results in a number of benefits that are not easily quantifiable but are important to the State. These benefits include avoidance of air pollutants from fossil fuel combustion and economic benefits arising from electricity price-hedging provided by renewable energy.

Developing renewable energy resources in New York will take some time, requiring the development of new industry infrastructures that include a workforce skilled in renewable technologies, renewable energy suppliers, and customer demand for renewable energy. With onsite generation, there is also the need to develop streamlined interconnection, siting, and permitting procedures.

The public's limited understanding of renewable energy technologies is another barrier to development of renewable energy. Customer education and successful demonstrations of renewable energy systems will be important to reducing perceived risks and increasing public acceptance.

RENEWABLE ENERGY USE IN NEW YORK

New York's primary energy use is presented in Table 1. Primary use includes electricity generation and energy use in the transportation, residential, industrial, and commercial sectors. Compared to the Unites States as a whole, New York uses a higher percentage of hydroelectric power and a substantially smaller percentage of coal.

Table 1: Primary Energy Use (Trillion Btu) in 1999 in New York and in the U.S.

	New York	United States
Petroleum	1,653 (38.6%)	37,960 (39.7%)
Natural Gas	1,251 (29.2%)	22,294 (23.3%)
Coal	188 (4.4%)	20,498 (21.4%)
Nuclear	393 (9.2%)	7,736 (8.1%)
Hydroelectric Power	265 (6.2%)	3,449 (3.6%)
Wood and Waste	174 (4.1%)	3,101 (3.2%)
Other (includes electricity generated from geothermal, wind, photovoltaic, and solar thermal energy)	1 (0%)	493 (0.5%)

Source: U.S. DOE. *State Energy Data Report:* 1999.

New York's grid-connected electricity generation capacity from renewable sources is shown in Table 2. The total capacity of currently operating sites is approximately 4,577 MW, of which 97% is from conventional hydropower. Two large projects represent 75% of the conventional hydropower in New York. The first of these projects is the 2,160 MW Niagara Power Project which uses water diverted from the Niagara River to produce electricity. The second is the 912 MW St. Lawrence-Franklin D. Roosevelt Power Project which spans the U.S.-Canadian border near Massena, New York. In addition, there are over 340 small hydropower projects throughout the State with a median size of 1.2 MW.

Table 2: Contribution of Renewable Energy Sources to New York State Electricity Supply

	Size Range (kW per Site)	No. of Installations	Median Size (kW)	Capacity (MW)	% of total
Hydroelectricity (excluding pumped storage)†	10 to 2,550,000	347	1,236	4,442.7	97.1%
Wood and Wood Waste†	300 to 19,800	4	9,625	38.5	0.8%
Agricultural Residue‡	3 to 150	4	65	0.3	0.0%
Landfill Gas§	1,000 to 5,500	19	2,000	46.0	1.0%
PV‡	.3 to 300	47	7.7	1.2	0.0%
Wind†	1 - 11,000	27	4.5	48.3	1.1%
Total				4,577.0	100.0%

†Source: New York State Independent System Operator. *2001 Load and Capacity Data.* 2001.
‡Source: National Renewable Energy Laboratory. *REPiS: The Renewable Electric Plant Information System.* 1999.
§Source: NYSERDA. *Internal Working Survey of Landfill Gas-to-Energy Projects in New York State.* 2001.

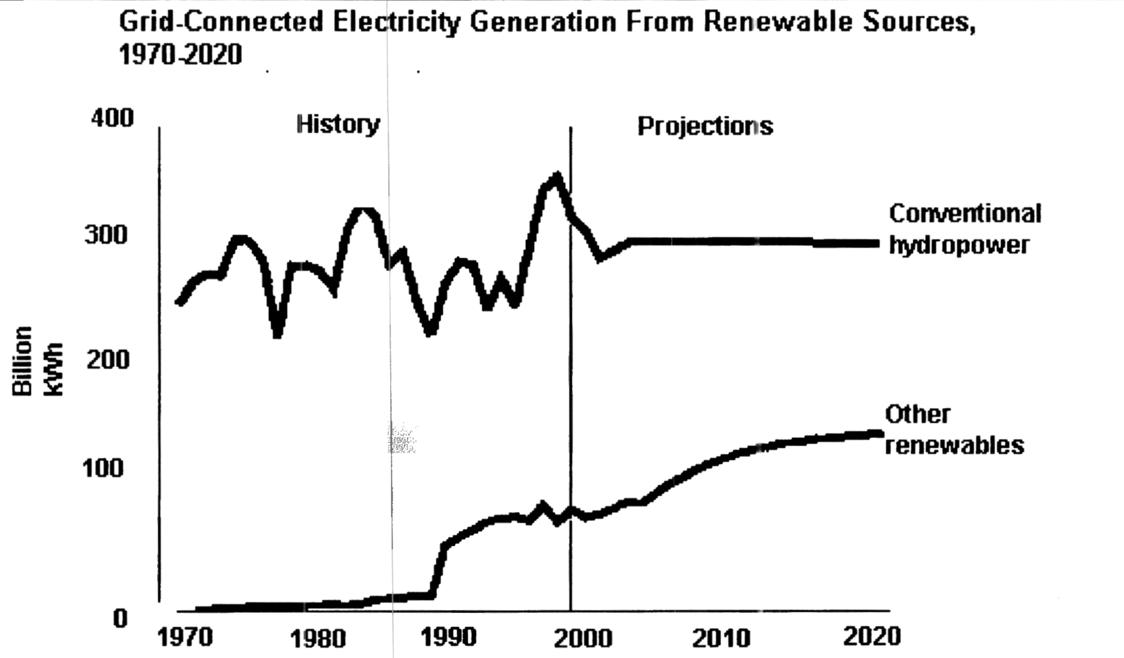
U.S. DEPARTMENT OF ENERGY NATIONAL FORECASTS

Forecast of U.S. Grid-Connected Electricity Generation From Renewables

As shown in Figure 1, under the reference case scenario in the Annual Energy Outlook 2002 (AEO2002), during the 20-year forecast:

> The combined U. S. generation from conventional hydropower and other renewables is expected to increase from 357 billion kWh in 2000 (9% of the total) to 464 billion kWh (9%) in 2020.
>
> Environmental and other requirements are projected to limit U.S. conventional hydroelectric generation to 304 billion kWh in 2020, or 6% of the total electricity supply.
>
> Generation from nonhydropower renewable energy sources is projected to increase from 81 billion kWh in 2000 (2% of U.S. electricity supply) to 160 billion kWh in 2020 (3% of U.S. electricity supply).

Figure 1



Source: U.S. DOE Annual Energy Outlook 2002.

The following are additional projections contained in AEO 2002:

U.S. electricity generation from biomass, including cogeneration and cofiring with coal, is projected to increase from 38 billion kWh in 2000 to 64 billion kWh (1% of total electricity supply) in 2020. Biomass is the largest source of nonhydroelectric renewable generation in the forecast.

Total U.S. installed wind capacity is expected to have reached 4,000 MW in 2001 and is projected to reach 9,000 MW in 2020. Generation from the wind plants, many of which are expected to be built in response to State mandates, is projected to increase from 10 billion kWh in 2001 to 24 billion kWh (less than 1% of total electricity supply) in 2020.

U.S. landfill gas capacity is projected to grow by more than 1,000 MW.

Solar technologies are not expected to make significant contributions to the U.S. electricity supplies through 2020. In total, central-station PV capacity and other grid-connected solar generators at customer sites are projected to provide 0.05% of total electricity generation in 2020.

RENEWABLE ENERGY PROGRAMS

National Initiatives

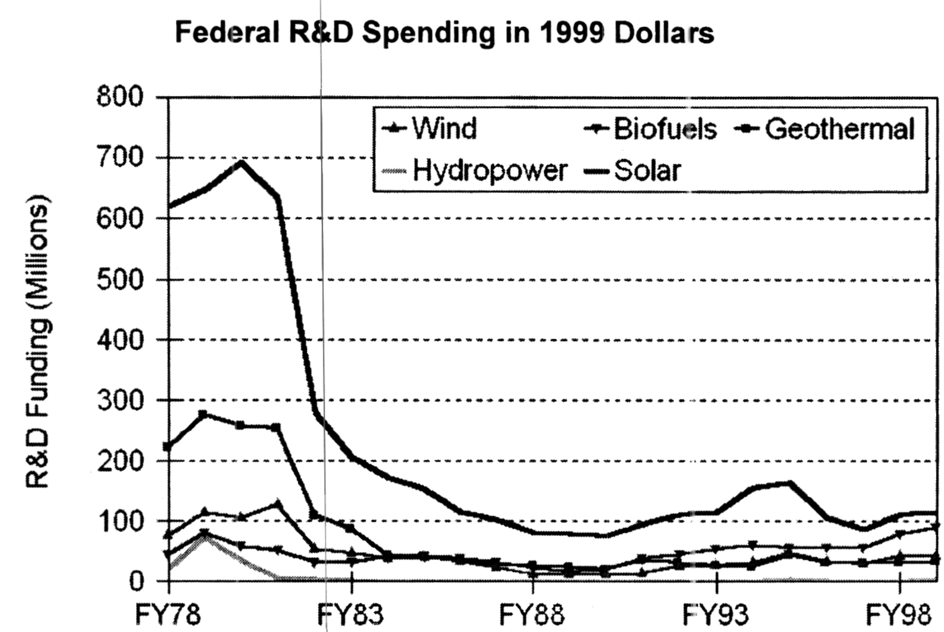
Public Utility Regulatory Policies Act (PURPA). After the 1973 oil crisis, changes in federal policy spurred the development of renewable technologies other than hydropower, the largest source of renewable power in the U.S. In 1978, Congress passed PURPA, which required utilities to purchase electricity from qualifying small power producers. Some states, particularly California and those in the Northeast, required utilities to sign contracts for purchase of electricity from renewable sources whenever electricity from those sources was expected to be less expensive over the long term than electricity from traditional sources. Over 12,000 MW of nonhydroelectric renewable generation capacity came on line under PURPA. During this time, the cost of renewable technologies decreased. Wind turbine costs, for example, decreased by more than 80%.

Financial Incentives. Federal financial incentives for renewable energy include tax credits and production incentive payments. The Energy Policy Act of 1992 established a permanent 10% business energy tax credit for investments in solar and geothermal equipment. As of 1999, new electricity generating facilities that use wind, biomass crops grown for energy, or poultry litter were eligible to receive a production tax credit of 1.5¢ per kWh (in 1992 dollars, adjusted for inflation) for 10 years. This credit expired on January 1, 2002. In March 2002, the U.S. Congress and President Bush extended the tax credit.[3] It will apply retroactively to installations placed in service since the beginning of 2002 and extend through the end of 2003.

Federal Research & Development. As shown in Figure 2, the U.S. Department of Energy (U.S. DOE) has historically provided more financing for solar (including solar thermal, passive solar, and photovoltaic) R&D efforts than for other renewable energy resources. However, funding for 1999 R&D spending for biomass energy systems (including both electric and transportation applications) increased by 64% compared to 1997. More than 35% of biomass energy systems R&D was used for ethanol-related projects.

[3] Senate action is anticipated.

Figure 2



Source: *U.S. DOE. Renewable Energy 2000 Issues and Trends. 2001.*

U.S. DOE's interest in ethanol can be traced to the Clean Air Act Amendments (CAAA) of 1990, which directed regions in severe non-attainment status for ground-level ozone to use oxygenated gasoline. Currently, there are two primary options for meeting the oxygen requirement. Ethanol, widely used by fuel manufactures in the Midwest, is made from corn and other biomass. The second option, methyl tertiary butyl ether (MTBE), is a petroleum-derived oxygenate. Approximately 25% of the gasoline sold in the U.S. today contains MTBE. However, as a result of surface and groundwater contamination, 13 states, including New York, have moved to discontinue the use of MTBE.

State Initiatives

State Incentives, Policies, and Programs. The Database of State Incentives for Renewable Energy (DSIRE), established in 1995, is an ongoing project to summarize state incentives, programs, and policies regarding renewable energy.[4] The project is

[4] www.dsireusa.org

funded by the U.S. DOE's Office of Power Technologies and is managed by the North Carolina Solar Center on behalf of the Interstate Renewable Energy Council. Selected DSIRE programs and policies are presented in Table A at the end of this section. As of October 2001, the database showed that many states have adopted laws in support of renewable energy. For example, 35 states have adopted net metering regulation, 15 states provide corporate tax incentives, and 13 states provide personal income tax incentives. Environmental Disclosure Rules, requiring load serving entities (LSE) to provide their customers with information on the fuel mix and the resulting emissions from the electricity supplied by the LSE, have been adopted by 18 states.

Renewable Portfolio Standards (RPS). Thirteen states - Arizona, Connecticut, Hawaii, Iowa, Maine, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, Pennsylvania, Texas, and Wisconsin - have adopted RPS mandates. An RPS establishes the requirement that a percentage of a state's electricity be generated from renewable resources. It typically defines the types of renewable resources that qualify and provides a schedule for reaching the desired goals. In addition, some programs establish a renewable credit trading program in which electric generators can either produce the required percentage of electricity from renewable sources or choose to purchase renewable credits from a generator with excess renewable generation.

System Benefits Charge Funds (SBC). Between 1998 and 2012, approximately \$3.5 billion will be collected for renewable energy development by 14 states with SBC funds.[5] The average annual funding is \$233 million over the next decade. In comparison, the federal fiscal year 2001 renewable energy budget was \$376 million. Except for California, Connecticut, Illinois, Montana, New York, Pennsylvania, Rhode Island, and Wisconsin, states still are in the early stages of obligating SBC funds allocated for renewable energy. The most popular program elements to date are financial incentives for large-scale renewable generation projects, customer-sited distributed generation programs, and renewable energy marketing (*i.e.*, efforts to develop a market with multiple energy suppliers providing energy generated from renewable sources).

RENEWABLE ENERGY SUPPORT ACTIVITIES IN NEW YORK

New York has developed a number of initiatives designed to increase the use of renewable energy. As a result of the restructuring of the electricity market, electricity

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[5] Lawrence Berkeley National Laboratory. *Clean Energy Funds: An Overview of State Support for Renewable Energy*. 2001.

customers can choose to use an energy supplier that provides renewable power. Furthermore, the decision to switch suppliers can now be made based on information provided by environmental disclosure labels. In addition, the State has allocated System Benefits Charge funding, administered by NYSERDA, to promote awareness and development of renewable energy. Executive Order 111 furthers the market development process by encouraging the use of long-term contracts that will be used to procure power for State agencies. The New York Power Authority (NYPA) and the Long Island Power Authority (LIPA) will also purchase renewable electricity, further supporting market development.

New York State Energy Research & Development Authority

Between July 1998 and June 2001, NYSERDA, the administrator of New York's public benefits program, invested over $14 million in renewable energy programs. The programs provided financial incentives for wind, PV, and biomass. For the period July 2001 to July 2006, NYSERDA will invest over $77.5 million of SBC funds to develop renewable energy in the State. Funding allocations and goals of the renewable program are shown in Table 3. The program will target both customer-sited renewable energy and wholesale market development.

Table 3: 2001-2006 New York System Benefits Charge Funding for Renewable Energy

	Funds allocated	Goals
End-use renewable market development (PV, small wind, small biomass)	$24 million	• Provide training for individuals involved in designing, installing, and inspecting renewable technology systems • Educate the marketplace on use and value of renewable energy • Ensure reliability of renewable technology system installations
Wholesale renewable market development (large wind, biomass, low-impact hydro)	$46 million	Develop wholesale market through: • Green marketing incentives • Renewable energy credit trading program • Green power auctions
Various uses	$7.5 million	
Total	$77.5 million	

The following are some of the renewable projects that NYSERDA has funded over the past three years:

Wind. NYSERDA-sponsored efforts to promote wind power in New York include:

> Site Development: NYSERDA is speeding up wind development in the State by sharing the cost of site development. These costs include those associated with locating desirable sites, collecting site-specific wind data, and conducting preliminary environmental impact reviews.
>
> Wind Map: NYSERDA has developed a wind map of New York that shows wind resource characteristics at three representative heights above the ground. The map is being used by developers interested in installing wind systems in the State.
>
> Wind Forecasting: With NYSERDA's assistance, a New York company is creating a wind forecasting model with the ability to predict wind speeds with useful accuracy at any location up to 48 hours in advance. Forecasting ability may increase the value of the energy produced by wind power plants.
>
> Wind Farms: By the end of 2001, NYSERDA had supported the construction and operation of 41.5 MW of in-State wind energy generation.[6] NYSERDA provided $2 million in funding to the Madison Wind Power Project, located in Madison County, which became operational in October 2000. NYSERDA provided $5 million in funding to another Madison County wind project in Fenner, about 25 miles east of Syracuse. This 30 MW facility began operating in November 2001. NYSERDA expects to have supported over 210 MW of installed wind capacity by 2006.
>
> Small Wind: NYSERDA is supporting small wind installations under 100 kW for the agriculture, municipal, and commercial sectors.
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> Transmission Access Study: NYSERDA is co-funding a study to investigate and evaluate transmission solutions for interconnecting wind power plants. The study will address permits required for installing transmission lines, interconnection procedures, contractual arrangements with transmission owners, and transmission and capacity pricing options.

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[6] Another 6.6 MW wind facility, constructed by the Niagara Mohawk Power Company using SBC funds, is located in Wethersfield, Wyoming County.

Building-Integrated PV Program. To foster installation of PV on commercial, industrial, and institutional buildings, NYSERDA is supporting projects that demonstrate innovative PV technologies and applications. The objectives of the program are to:

Familiarize mainstream architects, builders, and developers with PV-integrated building design;

Demonstrate the long-term performance and reliability of building-integrated PV systems;

Document installation and operating costs of building-integrated PV systems;

Lower customer's net cost; and

Reduce other barriers to the installation of building-integrated PV systems.

Residential PV Program. The goal of the residential PV program is to stimulate the residential PV market in New York. Near-term objectives of the program are: (1) to demonstrate the safety and reliability of grid-connected residential PV systems; (2) to reduce barriers to installing PV systems; and (3) to build market demand for residential PV.

Solar Energy Center at SUNY Farmingdale. This Nassau County campus is the site of one of the largest PV systems on Long Island. Over the past decade, NYSERDA has provided over $1 million in funding and technical assistance to install and maintain the 92-kW system.

Solar Electric and Wind Product Development. This program aims to develop in-State manufacturing capabilities for solar-electric and wind products to meet the growing State and worldwide demand for renewable energy. The program solicits proposals for solar electric and wind devices that will be manufactured in New York. The program targets technologies that will be commercialized within five years. Between 1996 and 1999, NYSERDA awarded $4.2 million to 14 companies to develop 18 products.

Fuel Cells.[7] Beginning in 1992, NYSERDA began partnering in Proton Exchange Membrane (PEM) fuel cell technology development with several New York companies

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[7] Although some fuel cells use fossil fuel as energy, fuel cell technology has been included in this assessmement due to its environmental benefits and potential to use bio-gas as a fuel source.

including Mechanical Technology Incorporated (predecessor of Plug Power, LLC). Between 1992 and 1997, NYSERDA invested over $3 million in fuel cell development and demonstrations including projects that developed a 50-kW PEM fuel cell for passenger cars. Cooperating with the New York Power Authority (NYPA), NYSERDA also helped demonstrate a 200-kW phosphoric acid fuel cell operating on bio-gas from a wastewater treatment plant in Yonkers, Westchester County. These early projects helped document the environmental benefits of fuel cells.

Currently, NYSERDA is administering a $6 million project, funded by the Clean Air/Clean Water Bond Act, to demonstrate 50 7-kW PEM fuel cells at 10 sites owned by the State. The fuel cells are manufactured by Plug Power, LLC in Latham, New York. Other anticipated NYSERDA fuel cell projects include:

> Installation and demonstration of a 250-kW fuel cell at Brookhaven National Laboratory on Long Island;
>
> Implementation of test fuel cells at a remote telecommunications site with a 5 kW load;
>
> A project to identify processes and issues surrounding installation of fuel cells for residential applications, including grid interconnection approval, site selection, site preparation, and operation and maintenance; and
>
> A project to develop a low cost, integrated manufacturing process for fuel cells.

Biomass. NYSERDA has historically supported biomass as a fuel supply and is currently involved in the following areas:

> Agricultural Sector: NYSERDA has current commitments for over $3.1 million[8] to fund 18 projects that will use anaerobic digester gas from farm wastes for co-generated electricity and heat. The total installed capacity from these projects will be approximately 1.6 MW.
>
> Willow Development: Since 1996, NYSERDA has been partnering with the Salix Consortium to spur the commercial harvesting of willows to be used as a sustainably-managed fuel source. NYSERDA has invested $1.4 million[9] in this

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[8] Total project cost is $8.8 million.

[9] Total project cost is $14.8 million.

project. Approximately 500 acres of willow have been planted to date, with enough biomass to generate about .75 MW of electricity. Co-firing of the first commercially harvested willow is planned for Summer 2002 at the Dunkirk power plant in Western New York.

Since 1999, NYSERDA has invested $850,000[10] in projects that seek to reduce dependence on petroleum by substituting bioresources for petroleum-based products, components, or processes. Examples of projects include improved enzyme production technology, bio-pesticides, polymers, and gasification of willow feedstock.

Other Incentives. Several of NYSERDA's energy efficiency programs, funded by SBC, provide incentives to end-users for renewable technologies:

Commercial/Industrial New Construction Program: The program provides incentives of up to $300,000 per project for design and installation of building-integrated PV and advanced solar and daylighting technologies. Advanced solar technologies include thermal storage systems, solar preheating systems, and flat plate solar collectors. Incentives are capped at 70% of the incremental cost of the design and installation.

Loan Fund Program: This program provides loans for renewable energy systems. The interest rate is reduced by 4.5% below the lender's usual rate.

Long Island Power Authority (LIPA)

LIPA is providing support for various renewable technologies through its Clean Energy Initiative. The implementation status of the renewable energy programs was released in June 2001. The following are a few highlights:

Solar/Photovoltaics.

Through the Solar Pioneer Program, LIPA is offering residential homeowners and small commercial customers a $3.00/watt rebate for grid-connected systems, with a maximum rebate of $15,000 per installation. The program also provides a LIPA-subsidized 6% loan to finance PV systems. As of December 2001, 14 PV systems had been installed.

LIPA is participating in the Million Solar Roofs Initiative and has committed to install 10,000 solar roofs on Long Island by the year 2010. To support this goal, LIPA is working to develop a certification process for PV installers.

[10] The total project cost is $2.3 million.

LIPA helped establish the Farmingdale Solar Energy Center at SUNY Farmingdale and is providing 70% co-funding for public information seminars and three-day workshops for electricians interested in installing PV systems.

LIPA installed a 20-kW grid-parallel Atlantis Energy Sunslate PV system (consisting of individual roof tiles each having a PV cell) and a geothermal heat pump system at the newly renovated New York State Nature Center located at Jones Beach State Park.

LIPA installed a 15.5-kW PV system at the New York Institute of Technology. The 48 roof-mounted solar panels use inverters to convert the DC power to AC power. Extensive weather-monitoring equipment installed at the site provides information on electricity production during varying environmental conditions (*e.g.*, wind speed and temperature).

Wind Energy.

Wind feasibility studies have been proposed in the Towns of Babylon, Hempstead, and Brookhaven. In Babylon, a contractor was engaged to conduct meteorological studies as well as the environmental and economic feasibility of siting wind turbines at the former Babylon landfill. In Hempstead, the Phase I analysis examined potential sites for wind generation within the Town including the former Oceanside and Merrick landfills, and two sites in the Point Lookout area. In Brookhaven, a site inspection was conducted at the landfill in preparation of a written proposal for a feasibility study on the installation of wind turbines and/or solar panels at the closed portion of the landfill site.

New York Power Authority

NYPA is actively engaged in efforts to preserve and protect the renewable power generated by New York's two largest hydroelectric projects. The St. Lawrence-FDR project has been operating with original equipment in the project powerhouse since 1958. The turbines will reach the end of their design life within the next 15 years and other equipment will require renovation or replacement in that time period. To address these concerns, NYPA, in1998, initiated a $254 million program to extend the life and modernize the generation equipment at St. Lawrence-FDR. Modernizing the first of the sixteen turbines has been completed and work on all the turbines is planned to be completed by 2013. Furthermore, the federal license for St. Lawrence-FDR expires in 2003. NYPA submitted an application for a new 50-year license to the Federal Energy Regulatory Commission (FERC) in October 2001.

The Niagara Power Project, which first generated power in 1961, includes the Robert Moses Niagara Power Plant. NYPA is upgrading and modernizing the 13 turbines at the Moses plant. The upgrade of eight units has been completed. The $293 million program, scheduled to be completed by 2006, will permit increased power production during periods of peak demand, but will not increase the project's overall output. The federal license for the Moses plant expires in 2007 and preliminary work on relicensing has begun.

In addition to hydroelectricity provided by the Niagara Power Project, the St. Lawrence-FDR Power Project, and five small hydropower projects across the State, NYPA is supporting a wide range of renewable energy technologies. For example,

As of 2001, NYPA had installed over 576 kW of PV at various municipalities at a cost of about $4.9 million.

NYPA completed four fuel cell projects totaling 800 kW at a cost of $3.2 million.

NYPA is currently working on a project to install eight more 200-kW fuel cells at wastewater facilities in New York City at a cost of $14 million. These fuel cells are part of an effort to offset the emissions from the Authority's PowerNow! gas turbine plants constructed in 2000 - 2001.

NYPA's plans for 2002 - 2004 include the following renewable energy technologies:

Anaerobic digester gas fuel cells;

Other fuel cells and microturbines;

Landfill gas-to-electricity;

PV; and

Wind power.

Legislative and Regulatory Initiatives

Executive Order 111. Governor Pataki's Executive Order 111, issued in 2001, directs State agencies and other affected entities to seek to increase their purchase of energy generated from specific renewable technologies to meet 10% of their energy requirements by 2005, and to increase that share to 20% by 2010. The specified renewable technologies are: wind, solar thermal, PV, sustainably-managed biomass, tidal, geothermal, methane waste, and fuel cells. NYSERDA, working with State agency representatives, have developed guidelines for implementation.[11]

The guidelines recommended that an existing agency or authority should serve as the central procurement agent to contract for the power and perform accounting and billing services for the State agencies. Use of a central procurement agent will reduce the likelihood of agencies competing against each other for renewable power, and ensure lower costs. Once the procurement agent is selected, the working group will work to address other critical issues related to renewable power requirements of the Order on an as-needed basis, including issues related to onsite generation of renewable electricity.

Net Metering Law. New York's net metering law (The Solar Choice Act of 1997, L. 1997, Ch. 339), allows residential electricity customers to offset their electricity use with power they send into the grid using PV equipment owned by the customer. New York's net metering legislation includes a 25% tax credit for the purchase and installation cost of a qualifying PV system, not to exceed $3,750. The maximum capacity allowed per customer is 10 kW. The law requires each utility to connect residentially-operated PV facilities until such connected power equals at least 0.1% of that utility's 1996 peak demand. Based on the 1997 filings made by the New York investor-owned utilities, total net metering capacity allowed under the law will be 23.4 MW. The capacity limit will be reviewed by the New York State Public Service Commission (PSC) in 2005 to determine whether it should be increased.

The PSC has developed uniform interconnection rules for net-metered systems. Systems must use type-tested inverters to be approved for interconnection. To date, 23 systems have been interconnected, representing total installed capacity of 48 kW. Another 16 systems representing 43 kW of installed capacity are in progress and another 8 systems representing 23 kW are in the application phase.[12]

New York Environmental Disclosure Program. The PSC now requires electricity providers throughout the State to include "environmental disclosure labeling" information in electricity bills at least twice during every twelve-month period. The label provides

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[11] NYSERDA. *Executive Order No. 111 "Green and Clean" State Buildings and Vehicles Guidelines.* December, 2001.

[12] Source: New York State Department of Public Service (DPS).

information on the mix of fuels used to generate the electricity sold by the customer's electricity supplier over a twelve-month period. Customers will see the percentage of their power that is coming from the following fuel sources: biomass, coal, natural gas, oil, hydropower, nuclear, solar, solid waste, and wind. In addition, the label will provide information on the emissions of three air pollutants associated with the electricity sold by the customer's supplier, comparing them to the statewide average for the given time period. All investor-owned electric utilities and energy services companies (ESCOs) providing retail electricity, as well as those municipal or cooperative electric utilities subject to PSC jurisdiction, are required to provide the environmental disclosure label. Environmental disclosure is likely to encourage electricity generators to provide more power from renewable resources.

Solar Easements. New York's real property law provides property owners the ability to create an easement for the purpose of preserving the exposure of a solar energy device. Any easement obtained in writing is subject to the same conveyance and instrument recording requirements as any other easements. New York General City codes allow local zoning boards to create rules regarding solar access.

Green Buildings Tax Credit. The Green Buildings Tax Credit Law, enacted in May 2000, contains provisions for fuel cells and PV arrays.[13] The law applies to property placed in service or that has received a final certificate of occupancy on or after January 1, 2001. An eligibility certificate from an architect or professional engineer, certifying that the building space remains green, is required annually.

The fuel cell component provides a 30% credit (6% per year over 5 years) for the capitalized cost of each fuel cell. The fuel cell must be serving green space and must use a qualifying alternative energy source. There is a cap of $1,000/kW of direct-current (DC)-rated capacity.

The PV component provides a 100% credit (20% per year over 5 years) for the incremental cost of building-integrated PV modules and a 25% credit (5% per year over 5 years) for the incremental cost of non-building-integrated PV modules. The system must be serving green space to qualify. There is a cap of $3/Watt of DC-rated capacity of the system.

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[13] http://www.dec.state.ny.us.

TECHNOLOGY CHARACTERIZATIONS AND ESTIMATES OF TECHNICAL POTENTIAL

In October 2001, NYSERDA initiated a renewable technology and resource assessment. The primary purpose of this assessment is to address the potential role of renewable energy resources in the State's energy future. This assessment will estimate the technical, economic, and achievable potential for the following renewable energy technologies: windpower, hydropower, biomass, landfill gas, PV, low temperature solar thermal, and fuel cells. Brief technology characterizations for these technologies and for ocean and passive solar are presented here. Preliminary estimates of technical potential in 2022 for windpower, hydropower, biomass, landfill gas, PV, low temperature solar thermal, and fuel cells, are also presented. Shown are potential generation (MWh), potential installed capacity (MW) based on the rated capacity of the equipment, and potential capacity coincident with summer and winter peaks. In the final report, expected to be released in Summer 2002, additional information on the methods and assumption used for the technical potential assessment will be provided along with more detailed technology characterizations and estimates of economic and achievable potential for the various technologies in 2007, 2012, and 2022.

Technical potential for renewable electricity technologies was defined as the upper limit of renewable electricity production and capacity that could be brought on-line over the next 20 years, without regard to cost, market acceptability, or policy constraints. Estimates of technical potential take into account availability of a renewable resource for electricity production and the availability of technology. Because the estimates of technical potential are not bound by cost, market, or policy constraints, they are not projections of anticipated market development. Rather, they represent an upper bound of what New York could theoretically attain from the renewable resource and technology combinations that were assessed for the on-going study. The portion of technical potential that could actually be achieved in New York will vary by renewable resource, depending on a variety of factors. Based on past experiences and studies, estimates of achievable potential are expected to fall in the range of 10% to 50% of technical potential estimates.

Windpower Characterization

During the 1980s, the wind industry attracted more than $2 billion of private capital, supporting the advances that made wind turbine systems economically viable. The life cycle cost of energy has decreased from more than 25 cents per kWh to the current range of 4 to 6 cents per kWh. During the 1990s, wind was the fastest-growing power source worldwide, with an average annual growth rate of 22.6%.

Wind Farms. Wind farms consist of 10 to 50 turbines in the 1 to 3 MW range that are connected to the electricity grid. Installed costs of wind farms, the lowest of the configuration types, occur in the range of $900/kW to $1200/kW. Still, wind farm development is an extremely capital-intensive undertaking, typically requiring partnerships that include state and federal agencies, utilities, and investment firms.

Cluster Installations. Cluster installations consist of two to 10 turbines connected to the grid. Turbine size ranges between 600 kW and 1.5 MW. The installed capital cost of clusters fall in the range of $1,200/kW to $1,500/kW – considerably higher than for wind farm installations. Compared to wind farms, cluster installations require less geographic area. They may also be more applicable for locations with limited transmission capacity because cluster installations can be connected to the grid at a lower voltage compared to wind farms.

Small Wind Systems. This category of wind systems are used in light industrial applications, on farms, in villages, and at remote sites. This class includes machines with power ratings typically in the 1 kW to 300 kW range. They most often are in remote locations and may or may not be grid-connected.

Because of their small size and individual nature, installed costs for small wind turbines are in the range of $1,500/kW to $6,000/kW. However, these machines, whether interconnected with the grid or not, have a high degree of siting flexibility and are available off-the-shelf.

Offshore Wind Installations. Offshore wind installations, yet untested in the U.S., are becoming an increasingly attractive option for wind energy production due to the concentration of population in coastal areas. Offshore installations are similar to wind farm configurations in that they generally consist of 10 to 50 utility-scale machines of 1 to 3 MW each. Long Island, with its higher-than-average energy costs and generous wind resources off its southern shores, represents a prime location for offshore wind energy development within the next two decades. The installed capacity technical potential for offshore wind off Long Island has been estimated to be 5,200 MW. However, permitting, aesthetics, and transmission issues pose potential barriers to such development in this area. The Great Lakes region may pose fewer permitting and interconnection issues by virtue of it being an area focused less on recreation than Long Island. Calculations considering wind resources and water depth restrictions show that there are approximately 2,500 MW of installed capacity technical potential off New York's Great Lakes shores, primarily on Lake Erie.

Windpower Technical Potential in New York

Four wind energy configurations were analyzed for their technical potential in 2022: wind farm installations, cluster installations, small wind installations, and offshore installations. The preliminary results are presented in Table 4.

Table 4: Technical Potential for Windpower in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Wind Farms	11,039,289	4,190	796	1,886
Cluster Installations	6,555,986	2,514	478	1,131
Small Wind	310,036	225	25	48
Offshore	28,038,004	10,100§	1,919	4,545
Total	45,943,314	17,029	3,218	7,610

§This represents the capacity off Long Island's shores and the Great Lakes region assuming that turbine size increases from the currently-available 2 MW to 5 MW.

A number of factors constrain the full exploitation of the wind's energy. Listed below are the major constraints considered in the development of technical potential values:

Land availability and land-use patterns;
Surface topography;
Offshore conditions;
Infrastructure constraints;
Environmental constraints;
Wind turbine capacity factor;
Wind turbine availability; and
Grid availability.

Hydropower Characterization

There are two types of conventional hydropower:

Run-of-river hydropower is electricity generated at dams where the amount of water discharged from the station is equal to inflow. At such stations, the amount of electricity able to be produced at any one time is primarily determined by the amount of water naturally available. As such, output from these stations cannot be predicted with precision.

Store-and-release hydropower plants are able to generate electricity, within seasonal limits of precipitation, largely on demand. As such, output from these stations can be predicted with greater precision. They also have the advantage of being able to be brought into service very quickly, and are used typically to serve peak demand.

In the past decade, hydroelectric capacity has been stagnant. This is largely attributable to the extensive legal and regulatory obstacles that characterize the hydroelectric industry. Therefore, the potential for future growth in the industry depends largely on the ability to implement public policies that eliminate or overcome these institutional obstacles.

The National Hydropower Association reports that from 1986 to 2001, some 246 projects were relicensed, resulting in an average U.S. annual hydroelectricity production loss of 4.23%. The challenge of relicensing will be felt in New York State as 83% of the State's hydroelectric capacity begin relicensing within the next 18 years. A list of these facilities is presented in Table B at the end of this section. In addition to those listed, 3 sites entered relicensing in 2000 and 2001, and ten sites which began relicensing in 1993 remain unsettled.

Hydroelectric power has the advantage that, once constructed, there is no fuel cost and therefore, minimum operating costs. For this reason, it is not unusual to find hydroelectric stations serving a significant portion of the onsite electrical load at energy-intensive industrial locations such as paper mills.

The environmental impacts of hydroelectric power include:

Fish mortality, primarily associated with passage through a turbine;

Obstacles to the passage of migratory fish;

Reduced water quality, typically associated with reduced dissolved oxygen concentrations;

Aquatic habitat impacts, related both to fluctuating river flows and to the creation of bypassed river reaches; and

Recreational impacts, particularly for white water boaters.

Sources of new hydropower capacity include the following categories of sites:

Repowering at Existing Hydroelectric Sites. This category, which involves upgrading existing equipment already installed and operating, generally results in the least environmental impact.

Installation of Additional Capacity at Existing Hydropower Stations. Many hydroelectric stations may have been built to serve particular loads, and were thus, not built to maximize potential output.

Installation of Hydroelectric Capacity at Existing Dams Used for Other Purposes. There are far more dams in the U.S. and in New York than there are hydroelectric stations. Many dams exist for other purposes including flood control, water supply, recreation, and irrigation. Adding hydroelectric capacity to existing dams saves the expense of dam construction and avoids the environmental and social impact which may result from new dam construction and impoundments. The National Hydropower Association reports that hydropower is installed at less than 3% of the 75,187 existing dams in the U.S.

Construction of New Dams for Hydroelectric Purposes. This category represents the type of hydroelectric project with the largest potential environmental impact. While the electricity benefits of these projects may be substantial, the likelihood of them being permitted is very small.

Hydropower Technical Potential in New York

Preliminary estimates of hydropower technical potential in 2022 is presented in Table 5.

Table 5: Technical Potential for Hydropower in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Repowering, Modernization, & Upgrade	715,434	408	147	192
Expanded Capacity at Existing Hydro Stations	1,571,303	286	103	134
New Capacity at Existing Dam sites	2,476,844	754	271	354
New Capacity at New Dam Sites	5,501,165	1,079	388	507
Existing as of 2002§	20,894,146	4,620	1,663	2,171
Total	31,158,892	7,147	2,572	3,358

§ Does not include pumped storage.

Theoretically, any site with flowing water and an elevation differential could be appropriate for construction of a new dam and installation of hydroelectric generating equipment. However, in practice, other physical constraints operate, including proximity to load and availability of electric transmission capability. Identification of plausible sites for expansion and new development were based on resource potential studies by FERC and the U.S. Army Corps of Engineers.

Biopower Characterization

The term biomass includes a wide-variety of closed-loop and open-loop organic energy resources. Closed-loop resources, which can be either woody (*e.g.*, hybrid poplar or willow) or herbaceous (*e.g.*, switchgrass), are those that are grown exclusively for the purpose of being consumed as an energy feedstock. Open-loop resources are typically either woody residues produced as byproducts in the wood processing industry or are clean woody waste materials intercepted from the municipal solid waste stream. A list of biomass resources is provided in Table 6.

Table 6: Biomass Energy Resources

Biomass Resource Class	Definition
Mill Residues	Wood residues produced in the primary and secondary wood products industries.
Silviculture (Forest harvesting) Residues	Wood residues produced from commercial logging and forest harvesting activities.
Silviculture (other than residues)	Wood, other than residues, from forest harvesting activities that could potentially be used for biopower (e.g., net annual growth).
Site Conversion Residues	Wood residues produced when forested lands are converted for other uses (e.g., for agriculture, roads, etc.).
Woody Yard Trimmings	Woody materials from yard trimming activities.
Construction & Demolition (C&D) Residues	The clean and available wood portion of the C&D waste stream.
Pallets and Other Waste Wood	Pallets, containers, discarded wood consumer products, scrap lumber (other than from construction and demolition).
Agricultural Residues	Corn stover and wheat straw residues.
Bio-energy Crops	Woody or herbaceous crops grown specifically for the solar energy stored during photosynthesis.
Cattle Manure, Poultry Litter, Hog Manure	Various on-farm animal manures that could be collected to reduce greenhouse gas emissions and to reduce pollution from agricultural runoff.
Wastewater Methane	Methane collected during the digestion of wastewater under methanogenic conditions.

A variety of technology types and scales can be used to produce electricity from biomass. In some cases, a particular biomass resource is more suitable for conversion to electricity using a particular technology. The main types of biopower technologies, their corresponding market applicability, and the types of feedstocks most frequently used with the technology are presented in Table 7.

Four technologies from Table 7 were selected for analysis. The guiding principle used in selecting the technologies was whether or not a given technology could have a significant impact on electricity markets within 20 years.

Table 7: Biopower Technologies

Technology	Electricity Markets	Potential Feedstocks
Customer-Sited Biomass Combined Heat and Power (CHP)	Primarily end-use, could involve sale into wholesale markets	Mill residues
Cofiring w/Coal	Wholesale	All, except manures and wastewater methane
Gasification	Wholesale or end-use	All, except wastewater methane. Most-likely to use C&D wood.
Direct-Fire, Stand-Alone	Wholesale	All, except manures and wastewater methane
Cofiring Gasified Biomass with Natural Gas or Coal	Wholesale	All, except manures
Small, Modular Biopower	End-use, could involve sale to wholesale markets	All
Bioliquids-to-Power	Wholesale or end-use	All, except manures and wastewater methane
Animal Manure Digesters	End-use, could involve sale to wholesale markets	Only manures
Wastewater Methane Combustion	Primarily end-use, could involve sale to wholesale markets	Wastewater methane only

Cofiring Biomass with Coal. Biomass can be combusted in a coal boiler, directly displacing a portion of the coal fed to the boiler. Typical application is central-station electricity production. Biomass can be blended with coal on the coal-pile (mixed feed) or injected via a separate biomass transfer system. Currently, there are 10.7 MW of active cofiring capacity at Greenidge Station along with an additional (previously active but currently unused) 11 MW of cofiring capacity at two other plants, Hickling Station and Jennison Station. The biomass handling equipment at Greenidge Station was recently upgraded, suggesting that cofiring there will continue. A 10-MW system was installed at Dunkirk Station and is currently awaiting approval for pre-commercial demonstration testing.

Biomass Gasification. Gasification of biomass prior to combustion improves emissions characteristics of biomass compared to direct-fire technology and biomass combined heat and power (CHP) applications. Biomass gasification is an emerging technology. Only a few gasifiers are in operation in the U.S. and there are no gasifiers operating in New York.

Customer-Sited Biomass CHP. The typical scale of this technology is 1 - 30 MW. CHP systems produce both heat (for steam) and electricity from biomass residues, increasing the efficiency of the biomass resource. The technology is typically employed at wood processing facilities (especially in the pulp and paper industry) that have large electricity and steam needs and a captive supply of biomass residues. Opportunities also exist in some food products manufacturing facilities. Biomass CHP is often an end-use application, but electricity can be sold into the wholesale market. The technology is well-developed and economical. In New York, there are two mills that employ biomass CHP. These mills represent 67.6 MW of CHP electric generation capacity.

Direct-Fire, Stand-Alone Wood-Fired Power Plants. The typical scale of this technology is 1-50 MW. The technology consists of combustion of wood fuel directly to produce power which is sold in the wholesale market. Efficiency is typically low (17 to 24%) relative to most other types of power plants. Technology is in widespread use in the U.S. In New York, five direct-fire, stand-alone wood-fired power plants were constructed beginning in the early 1970s. The capacity of these plants totals 41.8 MW. In 2001, only two direct-fire biomass plants were in operation, an 18-MW plant in Chateaugay and a 21-MW plant in Lyonsdale.

Biopower Technical Potential in New York

Preliminary estimates of biopower technical potential in 2022 are presented in Table 8.

Table 8: Technical Potential for Biopower in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Cofiring with Coal	4,347,051	652	641	652
Gasification	1,207,447	172	169	172
CHP	918,453	173	121	123
Direct-Fire	259,646	39	38	39
Total	6,732,597	1,036	969	986

The following assumptions and limiting factors were used in developing the technical potential for biopower:

Biomass used for purposes other than electricity (e.g. for wood products, animal bedding, and landscaping mulch) were excluded as being potentially available for fuel to generate electricity.

The amount of fuel potentially available from forest harvesting is limited to the amount of biomass produced from net annual growth in the forest. This assumptions ensures that fuel is available on a sustainable basis.

Of the biomass potentially available from construction and demolition (C&D), only the portion that is expected to be clean enough for use as fuel is considered as potential feedstock.

Specific biopower technologies and scales are matched with specific biomass feedstocks. CHP was assumed to largely use mill residues. Gasification was assumed to largely use clean wood from C&D waste.

The use of direct-fire burning was assumed not to grow beyond capacity in place as of 2002.

Biomass CHP applications in wood processing facilities were assumed to increase in the next 20 years.

The technical potential for cofiring was capped at 15% of coal-fired plant output.

Landfill Gas-to-Electricity Characterization

Landfill gas (LFG) is a product of natural decomposition of organic waste materials in an anaerobic (without oxygen) environment. This environment, formed as a result of daily trash deposition combined with the covering placed over the municipal solid waste (MSW) to prevent windblown litter, leads to microbial activity and the formation of landfill gas. Landfill gas is generally composed of about 50 percent methane and 50 percent carbon dioxide, with trace amounts of a variety of non-methane organic compounds (NMOC) in the parts per million range. LFG has approximately one-half the heating value of a typical natural gas and is considered to be a medium-Btu fuel.

Medium-Btu gas can be collected from landfills and used in applications such as boilers or for cofiring. The direct use of LFG as a medium-Btu fuel is the most efficient use of landfill gas but is seldom practiced because customers are not usually located near landfills. Landfill gas can also be cleaned and made into a high-Btu fuel that can be used to produce ethanol, methanol, high grade carbon dioxide for greenhouses, pipeline quality gas for commercial sale, liquified natural gas (LNG) for vehicle fuel, and compressed landfill gas (CLG). At Fresh Kills Landfill, a large facility located on Staten Island, high quality gas is being produced and sold to the local gas utility.

Technologies that produce electric power from landfill gas can be categorized as (1) large systems using combustion turbines or steam and combined cycle generation systems, (2) internal combustion engines, (3) microturbines, and (4) fuel cells.

<u>Large Systems.</u>

> Combustion Turbines. Combustion turbines are prime mover devices that combust LFG directly in the turbine. Turbines are available for LFG applications in 3 MW and 5 MW sizes from one major manufacturer. This size range of combustion turbine has been commercially available for some time and is used in numerous LFG applications.
>
> Steam and Combined Cycle Generation Systems. In selected situations, heat recovery steam generators (HRSG) are added to combustion turbine installations to improve fuel efficiency and generate additional power. Usually, the captured steam is run through a steam turbine-generator for secondary power generation (referred to as "combined cycle").

<u>Internal Combustion (I/C) Engines</u>. I/C engines are widely available in sizes ranging from 200 kW to around 1.2 MW for LFG applications. These engines are commercially available, cost-effective, and reliable.

<u>Microturbines</u>. Microturbines are a small combustion turbine recently offered for LFG applications in the 30 to 80 kW range. Four to six units can be combined to total 300 to 500 kW of installed capacity. The use of microturbines for LFG-to-electricity can be considered commercially established, but long-term reliability has not been confirmed yet (since the technology is new). Concerns exist about the lower quality of LFG (compared to natural gas) and the possible build-up over time of trace compounds (such as siloxanes) on turbine blades.

<u>Fuel Cells</u>. Fuel cells in the 100 to 200 kW size range are being pilot-tested at a few landfills. There are no commercial installations of fuel cells that use LFG as feedstock. The primary barrier to increased use of LFG with fuel cells is the cost required

to pre-treat the gas to remove sulfides and other trace compounds that could damage the fuel cell. Due to the high cost of pretreating the gas, fuel cells were not included in the technical potential assessment.

LFG-to-Electricity Technical Potential in New York

Preliminary estimates of the technical potential for selected LFG applications are presented in Table 9.

Table 9: Technical Potential LFG-to-Electricity in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Large Systems	158,469	19	19	19
Internal Combustion Engines	862,071	104	104	104
Microturbines	98,885	12	12	12
Total	1,119,425	135	135	135

Technical potential for landfill gas-to-electricity (LFGE) is based on the amount of landfill gas expected to be generated at major municipal solid waste landfills in New York. The technical potential represents the amount of electricity theoretically possible from the landfills and includes existing LFG-to-electricity facilities, expansion at some existing facilities, and projected new facilities. Data from the New York State Department of Environmental Conservation (DEC) on projections of future landfilling were used to estimate landfill gas generation.

The following assumptions and limiting factors were applied in developing the technical potential for LFG-to-electricity:

> The amount of municipal solid waste (MSW) generated in New York is projected to remain fairly constant. The amount MSW landfilled is projected to increase slightly from the amount landfilled in 2002.
>
> Combustion turbines and steam/combined cycle systems in the range of 3 to 15 MW are projected to recover 20% of the landfill gas.

Internal combustion engines in the range of 400 kW to 5 MW are projected to recover 68% of the landfill gas.

Microturbines in the range of 30 kW to 600 kW are projected to recover 12% of the landfill gas.

PV Characterization

Currently, the largest world-wide market for PV is the off-grid market, which takes advantage of PV's ability to function as a complete stand-alone electrical system. PV requires capital investment in the range of $5 to $12 per Watt, but initial costs are offset by low operating costs. The 20-year life-cycle cost rangesfrom 20¢ to 50¢ per kWh. A home installation may need 2 to 5 KW of power, and at $12 per Watt, the cost ranges from $24,000 to $60,000. However, combined with the high cost of a rural distribution line and lower land costs in remote areas, PV may be an economic alternative to grid-connected power in some locations.

Four PV application categories were examined for technical potential: (1) residential PV, (2) commercial and industrial (C/I) PV with solar load controller, (3) C/I PV without solar load controller, and (4) building-integrated PV. Solar load control is an approach to maximize the peak shaving capacity of PV systems by matching electricity demand to PV output. For example, building cooling set-points can be controlled to match demand to PV output.

Technical Potential for Photovoltaics In New York

Preliminary estimates of PV technical potential in 2022 are presented in Table 10.

The market development and application of solar technologies will be greatly affected by cost factors that are not considered in the estimation of technical potential. The primary factor underlying the technical potential was the availability of sites. Solar technologies are best suited for generation near points of electricity use. Therefore, deployable spaces were used as an upper limit for technology deployment. These spaces included roofs, facades, parking lots, and exclusion zones.

Table 10: Technical Potential for PV in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Residential PV	23,802,520	15,080	2,275	555
C&I PV w/Solar Load Controller	17,036,362	10,275	5,155	687
C&I PV w/o Solar Load Controller	11,357,575	6,850	1,084	202
C&I Building-Integrated PV	850,297	796	41	35
Total	53,046,753	33,001	8,555	1,479

Without storage capability, PV output is not available to meet certain loads, such as nighttime demands or winter heating loads. PV is an excellent match for peak summer loads which are driven by cooling demands. However, as PV generation increases to represent a larger fraction (*e.g.*, greater than 20%) of total system demand, PV's effective capacity (*i.e.*, capacity to meet system peak demand), is reduced because PV will be used to power more of the non-cooling portion of the peak load.

Low Temperature[14] Solar Thermal Characterization

Solar Hot Water. Solar heat can be used to displace electricity used for water heating. Solar hot water systems can serve the domestic hot water loads of residential buildings, commercial and school buildings, and provide service hot water or process hot water for industrial sites. Single-family residential solar hot water system packages are available from several vendors. Larger systems require site-specific installations.

Solar Absorption Cooling. Solar heat can be used to displace electricity used for cooling. Absorption cooling devices use a heat source, such as natural gas or a large solar collector, to evaporate the already-pressurized refrigerant from an absorbent/refrigerant mixture. Condensation of vapors provides the same cooling effect as that provided by mechanical cooling systems. Although absorption coolers require electricity for pumping the refrigerant, the amount is very small compared to that consumed by a compressor in a

[14] High-temperature solar thermal applications are not applicable for New York due to low solar insolation values.

conventional electric air conditioner or refrigerator. Systems are typically sized to carry the full air conditioning load during sunny periods.

Solar Ventilation Air Heating. Solar heat can be used to displace electricity used for heating ventilation air.

Technical Potential for Low-Temperature Solar Thermal in New York

Preliminary estimates of the technical potential for low-temperature solar applications in 2022 is provided in Table 11.

Table 11: Technical Potential for Low-Temperature Solar in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Residential Domestic Hot Water	1,435,521	849	218	104
Commercial Domestic Hot Water	781,762	463	119	57
C&I Air Preheating	216,875	445	0	69
Solar Absorption Cooling	4,022,362	6,205	2,975	0
Total	6,456,520	7,962	3,331	230

The factors underlying the technical potential are solar resource and suitable available space. For the solar thermal technologies, the technical potential cannot exceed the electric energy consumption that will be displaced by the solar technologies.

Fuel Cells Characterization

A fuel cell generates electricity through an electrochemical reaction that requires an external source of hydrogen, either from a hydrogen storage system or an integral reactor that produces hydrogen from hydrocarbon fuels, such as natural gas or methanol. Since fuel cells employ a chemical process instead of a combustion process, air emissions are typically much lower than those from combustion technologies. A variety of fuels can be used for fuel cells.

Most stationary[15] fuel cell systems will be installed with heat recovery for creating hot water or steam. A CHP fuel cell system offers the inherent environmental benefits of fuel cells along with much higher overall efficiencies obtained by using the heat output of the system. Despite these benefits, fuel cell CHP remains an underutilized technology hindered by a number of barriers which can be summarized as: (1) permitting systems that are complex, time consuming, and varied, (2) difficult interconnection arrangements with utilities; and (3) depreciation schedules that do not reflect the true life of fuel cells and other CHP assets.

There are several different types of fuel cells, each believed to have advantages over the other types in specific applications:

Molten Carbonate (MOFC). This type of fuel cell offers a very high fuel-to-electricity efficiency and can also use fossil fuels. They operate at very high temperatures (1,200 Fahrenheit) and therefore cannot be used in small scale applications. This type of fuel cell is considered viable for increasing the efficiency of electricity production at large-scale power plants.

Phosphoric Acid Fuel Cells (PAFC). These fuel cells, which use phosphoric acid as an electrolyte, is the most commercially researched and developed type of fuel cell. They tend to be heavy, making them less suitable for use in small automobiles. However, they can potentially be used in buses, other fleet vehicles, and trains.

Proton Exchange Membrane (PEM): PEM fuel cells, designed to function at fairly low temperatures (200° Fahrenheit), are the most promising fuel cells for use in automobiles due to their ability to shift their power output on demand. Also, they can start-up very quickly, making them ideal for use in small devices and electronic applications.

Solid Oxide Fuel Cells (SOFC). This technology can be operated at high enough temperatures to eliminate the use of a fuel reformer. The higher operating temperatures and higher electrical efficiency (40-50%) of this type of fuel cell will make it an attractive electricity and heat generating option once initial manufacturing difficulties are overcome.

[15] Non-stationary fuel cells are those used for transportation.

The following two technologies represent recent developments in fuel cell technology:

Direct Methanol Fuel Cells. In direct methanol fuel cells, the hydrogen is derived directly from the methanol, eliminating the need to store hydrogen.

Regenerative Fuel Cells. These fuel cells use water as a fuel. The water is split using solar energy to produce hydrogen and oxygen which are used to create a current that can power an automobile or other objects. Water and heat are generated as by-products. The water, however, can be recycled and reused in the fuel cell to generate more electricity.

Technical Potential for Fuel Cells in New York State

Preliminary estimates of the technical potential for fuel cells in 2022 is presented in Table 12.

Table 12: Technical Potential for Fuel Cells in 2022

	Generation (MWh)	Installed Capacity (MW)	Summer Peak Capacity (MW)	Winter Peak Capacity (MW)
Proton Exchange Membrane	3,327,301	649	431	469
Phosphoric Acid	6,504,194	784	786	786
Solid Oxide	7,709,599	929	932	932
Molten Carbonate	20,711,931	2,495	2,503	2,503
Total	38,253,024	4,857	4,653	4,691

The following assumptions were applied to the technical potential estimates for fuel cells:

For phosphoric acid fuel cells, technical potential is estimated to be 20% of the electric energy consumption of the applicable sectors.

For solid oxide fuel cells, the technical potential is estimated to be 50% of the electric energy consumption of the applicable sectors.

For molten carbonate fuel cells, the technical potential is estimated to be 40% of the electric energy consumption of the applicable sectors.

Passive Solar Characterization[16]

Passive solar refers to the use of the sun's energy without installing mechanical devices. Buildings designed for passive solar incorporate design features such as large south-facing windows and building materials that absorb and slowly release the sun's heat. The three type of passive applications are:

Passive Solar Heating. The simplest passive design is the direct gain system in which the sun shines directly into a building, thereby providing heat. The sun's heat is stored by the building's inherent thermal mass in materials such as concrete, stone floor slabs, or masonry partitions that hold and slowly release heat. Incorporating passive solar designs can reduce heating bills as much as 50%.

Passive Solar Cooling. Many passive solar designs include natural ventilation for cooling. By installing casement or other operable windows for passive solar gain and adding vertical panels, called "wing walls," perpendicular to the wall on the windward side of the house, the natural breeze in the interior is accelerated. Another passive solar cooling device is the thermal chimney, which can be designed like a smoke chimney to vent hot air from the house through the roof.

Daylighting. Daylighting is using natural sunlight to light a building interior. In addition to south-facing windows and skylights, clerestory windows, which are rows of windows near the roofline, can let light into north-facing rooms and upper levels. An open floor plan allows the light to reach throughout the building. Daylighting in businesses and commercial buildings can result in substantial savings on electric bills. Furthermore, natural light provides high-quality lighting that can improve productivity and health. Studies have shown that daylighting in schools can improve student grades and attendance.

[16] This application is not included in the on-going renewable energy potential study.

Ocean Power Characterization[17]

Ocean energy is available from tides, waves, and surface heat. Areas with dramatic tidal changes within a bay offer the best potential for tidal power (such as the Bay of Fundy, Canada and Britain's Severn Estuary). Despite a relatively small ocean shore line, Long Island may possess the potential for ocean power. Seawater has a higher density than air so that currents of 5-8 knots can generate as much energy as winds of much higher velocity. As of September 2001, the Connecticut Clean Energy Fund was investigating the south shore of Long Island as a potential site for a Connecticut firm to build a tidal power station.

In 2001, the Connecticut Clean Energy Fund and the Massachusetts Renewable Energy Trust conducted a study to examine the wave energy potential in the area between Portland, Maine and New York City. The report stated that although New York does not have the geographics necessary for wave energy devices developed for the Atlantic coasts of Europe, wave energy technology originating in Japan may be suitable for Southern New England due to the similarity in their geographic positions relative to storm tracks.

FINDINGS AND CONCLUSIONS

The State has abundant untapped renewable energy resource potential for additional wind, solar, and biomass, as well as more efficient hydropower at existing dams.

Higher prices for renewable energy will continue to be a barrier to widespread adoption of renewable energy technologies. To foster greater investment in renewable energy-based distributed generation technologies, interconnection rules need to be monitored and periodically reevaluated with the goal of easing interconnections without compromising reliability and system protection, and stand-by rates need to be fair and equitable.

The cost of renewable energy technologies will continue to be dependent on national and global renewable market development activities. Commercialization efforts, and hence, product prices are currently driven by national and worldwide

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This technology is not included in the on-going renewable energy potential study.

demand for renewable energy. As a consequence, it is important for the State to collaborate with other states and the Federal government to develop policies that support renewable energy technology and industry development.

The State is making significant progress compared to other states in the promotion of renewable energy. By November 2001, New York had 48 megawatts of installed wind capacity, the highest capacity in any Northeastern state. The State is continuing to build a sustainable renewable energy industry by promoting growth in consumer demand, supporting consumer education, constructing and operating renewable energy facilities, and reducing regulatory barriers that might hinder greater development of renewable energy resources in the State.

The State's continued support for renewable energy is necessary to increase consumer interest, advance the development of renewable energy technologies, and achieve widespread commercialization and use.

Table A: Summary of Selected State-Level Renewable Energy Initiatives

Initiative	Description	Number of States Providing Incentive	Available in New York
Corporate Tax Incentives	Allow corporations to receive credits or deductions ranging from 10% to 35% against the cost of renewable energy equipment.	15	Yes
Personal Income Tax Incentives	Tax credits or deductions to cover the expense of purchasing and installing renewable energy equipment.	13	Yes
Property Tax Provisions	Provides that the added-value of the renewable device to be excluded from the valuation of the property for taxation purposes.	15	No
Sales Tax Incentives	Exemption from the state sales tax for the cost of renewable energy equipment.	14	Yes
Contractor Licensing	Licensing of renewable energy contractors	12	No
Equipment Certifications	Statutes requiring renewable energy equipment to meet certain standards	12	No
Environmental Disclosure Rules	Requirement that utilities provide their customers with information on fuel mix and emissions statistics.	18	Yes, as of Dec. 2001
Line Extension Analysis	Requires utilities to provide their customers with information on on-site renewable options when a line-extension is requested.	5	Yes
Net Metering Rule	For those consumers who have their own electricity generating units, net metering allows customer to use the excess generation to offset electricity that would have been purchased at the retail rate.		Yes
Solar and Wind Access Laws	Statutes providing for solar or wind easement rights.	33	Yes

Source: Database of State Incentives for Renewable Energy (DSIRE).

Table B: Hydroelectric Relicensing Schedule in New York State

License Expiration Date	Project Name	Owner	County	River	KW
1/31/02	Raquette	Orion	St. Lawrence	Raquette	101,250
10/31/02	Fowler #7	HDG	St. Lawrence	Oswegatchie	900
12/31/02	Hailesboro #4	HDG	St. Lawrence	Oswegatchie	1,490
11/1/02	Rainbow Falls	NYSEG	Clinton	Ausable	2,640
2/28/03	Keuka	NYSEG	Steuben	Mud Creek	2,000
10/31/03	St Lawrence-FDR	NYPA	St. Lawrence	St. Lawrence	912,000
1/31/04	Newton Falls	Newton Falls,	St. Lawrence	Oswegatchie	2,220
8/31/05	Stuyvesant Falls	Orion	Columbia	Kinderhook	2,800
10/31/05	Piercefield	Orion	St. Lawrence	Raquette	2,700
4/12/06	Saranac	NYSEG	Clinton	Saranac	38,950
11/30/06	North Fork	Orion	Franklin	Salmon	1,000
8/31/07	Robert Moses	NYPA	Niagara	Niagara	2,755,000
3/2/11	Green Hydro	Orion	Albany	Hudson	6,000
3/31/12	Natural Dam	Fonda Group	St. Lawrence	Oswegatchie	1,020
5/31/12	Emeryville	Hampshire	St. Lawrence	Oswegatchie	3,540
12/31/12	Oswegatchie	Orion	St. Lawrence	Oswegatchie	28,471
6/30/15	Chasm	Orion	Franklin	Salmon	3,350
2/28/19	Colliersville	HDG	Otsego	N. Br.	1,450
4/30/19	Blenheim Gilboa	NYPA	Schoharie	Schoharie Cr	1,000,000
9/30/19	Lower Beaver Falls	Beaver Falls	Lewis	Beaver	1,000
3/31/20	Granby	Orion	Oswego	Oswego	10,000
				TOTAL	4,877,781